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The Accumulation Conversation

How to Increase Throughput using Buffer Zones and Accumulation

Discover the conveyor's role in production line accumulation, best practices in using buffering systems and mistakes to avoid when planning accumulation.

Faster changeover, more automation and greater line speed are persistent issues that Operations and Manufacturing Managers face in production line planning. But even the fastest machines and quickest changeover processes may not optimize production line volume. The true efficiency of the system is the output at the end of the line. Buffering and accumulation are the keys to making high speed lines work successfully to maximize throughput.

Conveyor Speak

Accumulation is the process of collecting products for temporary storage. Buffering is the ability to collect products that can be delivered at a different rate than it is received. Both conveyors and accumulators can be designed with buffering capability. One more definition, throughput, refers to the production volume of the entire line from beginning to end.

Short Delays Add Up

Short delays can happen any time on just about any type of equipment. Priming the labelers, cartoners or case-packers are planned delays, but unplanned delays can also occur, such as an incorrectly oriented package jamming in a wrapper. The point is that short delays add up. For example: A half-dozen stops at 10 minutes per stop in an eight hour shift, translates to one hour of lost production.

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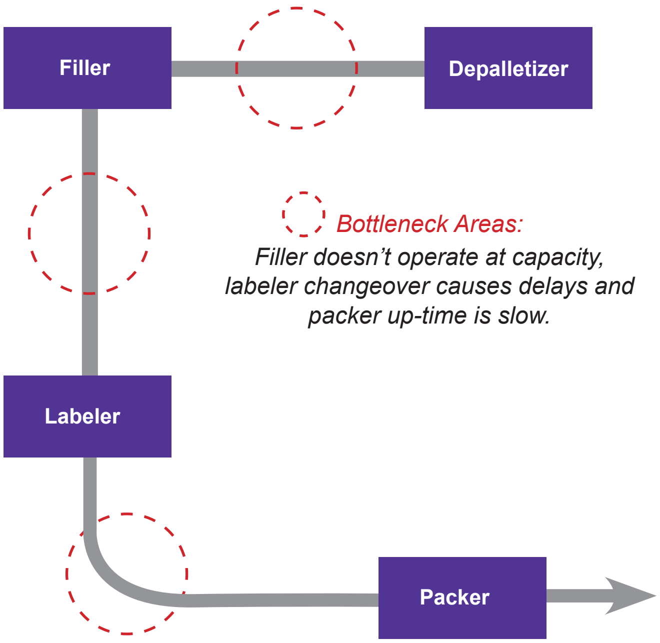
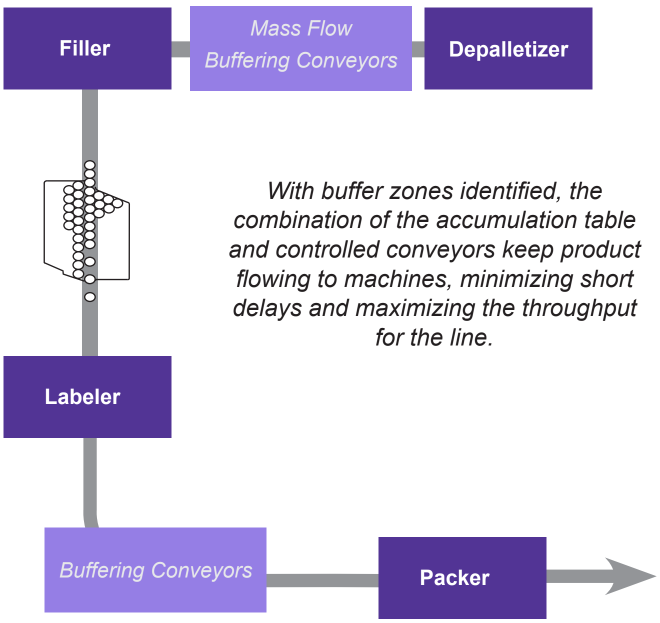
Accumulation Efficiencies

Layout A
Lost Efficiency



Layout A illustrates four machines in a production line, each operating at 90% efficiency. Whether planned or unplanned, the machines in this example almost never shut down at the same time, resulting in a loss of 40% efficiency.

Layout B
Reclaimed Efficiency

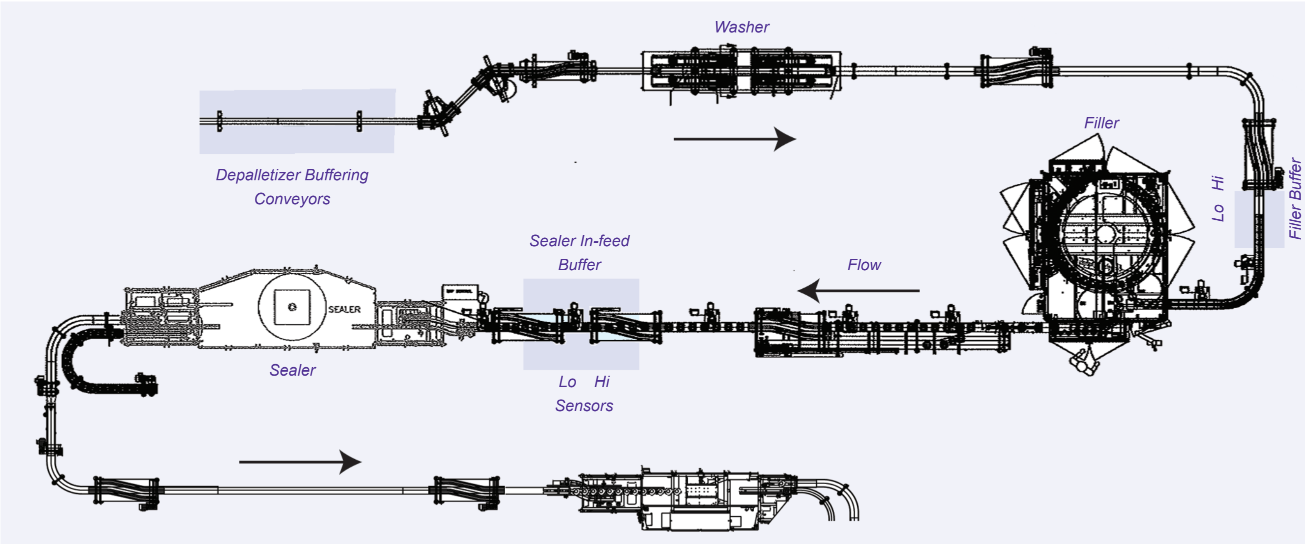


Layout B shows the same four machine scenario with accumulation and buffering planned into the line, resulting in reclaiming the lost efficiency.

About Bottlenecks

Knowing the location of the bottlenecks in the packaging line will help determine where the buffer locations are needed and the accumulation capacity required. This is typically accomplished by identifying the expected stoppages and their duration. The rate of the line will help to determine the upper limits for each machine. Manufacturers also conduct time studies, or use simulation techniques to determine accumulation requirements. Also bear in mind that machines can have completely different efficiencies depending on changes in the environmental conditions of the plant. Common bottlenecks in packaging production lines are operations of bulk depalletizers, fillers, wrappers, cartoners, case packers and palletizers.

Case Study: No Room for Accumulation



This buffering solution increased overall production by more than 5%.

In this case, a dry beverage manufacturer needed to coordinate several high speed pieces of equipment and reduce stoppages created by inconsistent container delivery, while occupying the original floor space. The core challenges included the close coupling of the can filler to the sealer, and the long transport distance from the depalletizer to the filler. The distance between the filler and the sealer allowed for only a few feet of conveyor buffering at the sealer's in-feed, while still allowing room for a full purge of product from the filler should the sealer shut down. Nercon developed a control scheme centered around the filler's speed setting. The conveyor PLC monitored the filler's rate; used that rate to set base conveyor speeds and then directly controlled the unit-per-minute rate of the sealer to maintain the sealer's required prime for maximum efficiency. This resulted in a 10 ft. long high speed zone that reduced downtime due to starving the sealer or product back up into the filler.

The other test was to ensure a constant container in-feed of the filler, without excessive product back pressure. This required an intermediate conveyor to serve as a buffering conveyor between the intermittent depalletizer discharge and the filler in-feed. The speeds of the buffer conveyor and the conveyors through the washer and into the filler were again based upon the filler's speed set point. The buffer speed was designed to produce a constant state of back-to-back product. The filler in-feed conveyor speed pulled gaps between the products to allow for Hi-Lo sensor detection. As a result, the conveyor speeds were modulated to deliver cans at a rate both faster and slower than the filler's set speed to maintain the required prime.

About Conveyors

Tabletop, mat-style plastic belt, fabric belt or roller belt conveyors can be used in buffer zones. To function as accumulating or buffering conveyors, the system must employ low friction practices. Low-friction conveying systems result in less back-pressure on the products, which allows for greater accumulation lengths without product damage. Chain products that utilize non-driven rollers offer greatly reduced friction. Conveyors can also be engineered with "zero pressure" accumulation zones, which raises the product off the conveyor chain to eliminate pressure on the product.

Re-Flow Accumulation Table showing In-Line Accumulation

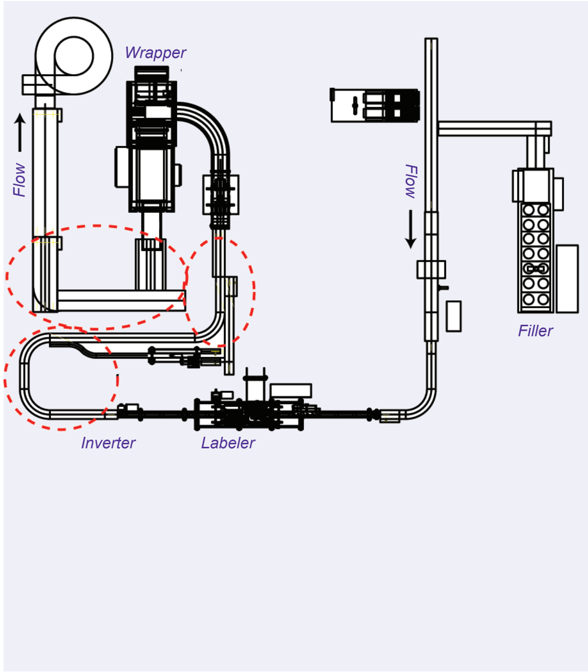
Buffering conveyors are a series of conveyors that provide a degree of accumulation capability above and beyond their normal transport function. Using a combination of speed, rate and back pressure control, buffering conveyors will allow for minor stoppages in downstream equipment without having to immediately stop upstream equipment. Between machines, a well planned layout will provide the most "buffering" possibilities for the production line. Their capacity to accumulate is determined by how fast the conveyor is running over nominal production rates, and the product's ability to withstand the additional pressure that results from the accumulation process.

A simple example of highlighting the use of buffering conveyors: If product length is 12" and the rate is 60 units per minute, a 60 foot long conveyor with a speed of 60 feet per minute will always be completely full and have zero room for buffering. Double the conveyor speed from 60 FPM to 120 FPM, and the result provides enough space on that same conveyor to accumulate 30 products at any given time which will create efficiencies with downstream equipment.

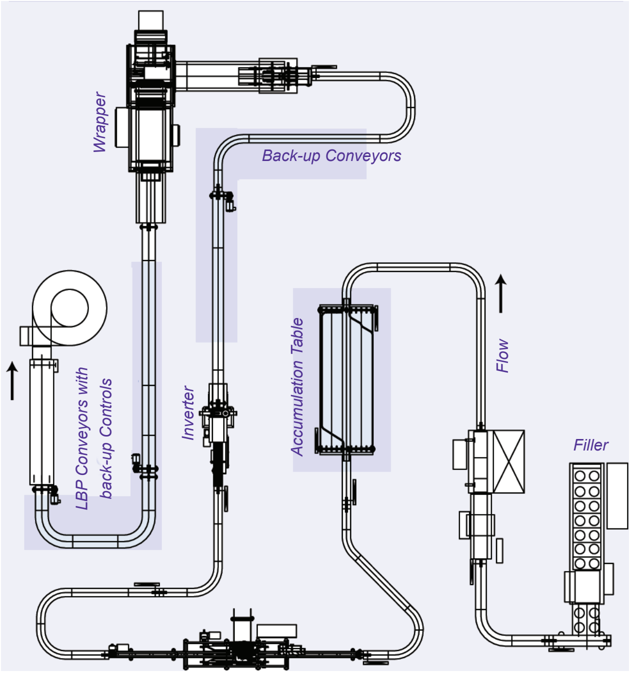
While some buffering zones can be handled by transport conveyors, other zones may require a dedicated piece of accumulation machinery. The most important aspect of any buffering system is that, when running normally, the downstream equipment must run faster than the upstream equipment in order to purge the buffered product in preparation of the next buffering cycle. Without this extra downstream "de-accumulation" capacity, a buffering system becomes a one time buffer that can only be purged when the upstream equipment is stopped.

Case Study: Close Coupling Bottlenecks

Before



After



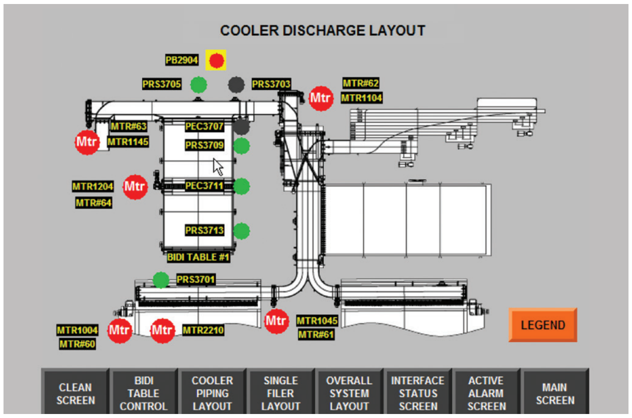
The equipment and controls solution increased efficiencies by 20%.

In this case, the packaging operation had an existing line where the equipment was too close coupled to operate efficiently. This is an excellent example of why back-to-back equipment will not work on a production line. As shown in the red dotted lines above, the “before” layout does not have a buffering plan to allow for the thresholds of the wrapper, labeler and filler. Any downed equipment issue would require a total system shut-down, resulting in lost efficiency and unnecessary product and packaging waste.

The New Packaging Line (see “after” layout above,) an accumulation table was added to the line which allows the filler to continue production during downstream stoppages. Once the downstream equipment is back on-line, the accumulation table keeps a continuous flow to the labeler. Conveyors with back-up sensors and buffering controls allow the wrapper and labeler to operate at maximum efficiency. The LBP (Low Back Pressure) conveyors with back-up sensors also control the buffer between the wrapper and downstream equipment. The new layout is designed to keep the filler and the rest of the equipment running continuously, resulting in more than a 20% increase of efficiency for the line.

Accumulation Basics

The accumulation capacity required, available floor space or ceiling heights, type of package and line speeds will help to determine the types of accumulation equipment best suited for the application. Accumulation equipment can be First-In, First-Out (FIFO) or First-In, Last-Out (FILO) and includes: standard and alpine conveyors, re-circulating tables, bi-directional tables, vertical accumulators, serpentine and spiral accumulators, and multi-tiered accumulation systems. They can also be designed for in-line or off-line accumulation.



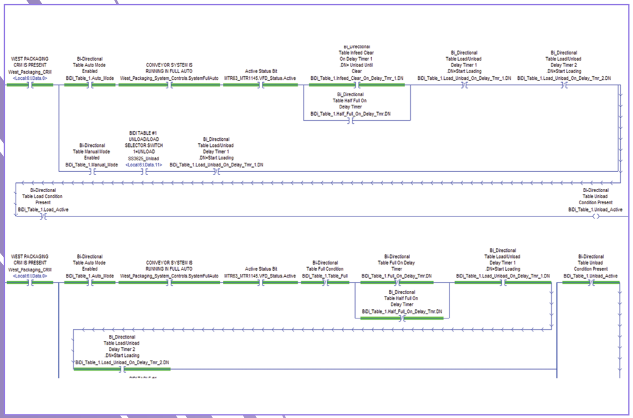
HMI (Human Machine Interface) operator screen showing a multiple cooler discharge system utilizing bi-directional accumulation tables.

Mistakes to Avoid

Placing equipment and machines back-to-back in a production line without planning for machine thresholds is the first mistake. Such a system running at high-speed will end up costing more in manual intervention than having planned accumulation in the first place. The other scenario is that the system would have to be slowed down to the slowest machine.

Another common mistake is not having enough conveyors to feed accumulating equipment or packaging machines. In-feed conveyors need to be able to have sufficient products and speeds in order to prime the machine to maintain the reliability of the process.

As previously mentioned, make sure that downstream equipment runs fast enough to clear the buffer zones. If the buffer zones cannot clear, then the accumulator becomes a bottleneck.



Logic controls monitor product flow, product back-up and non-operating machinery in a production line.

This system uses expanded and optimized electrical controls to integrate all thermal controls and the processes in the high speed sauce line. The line was fully automated an menu driven with multiple HMI's.

In some cases, buffering solutions are not sufficiently designed to handle the flux of short down times needed to service equipment on the line. In the design phase of the project, purchase the right equipment and conveyors needed to meet production goals. The right equipment with the right capabilities will not only meet throughput requirements, but will also provide the best cost to benefit ratio for the lifetime of the system. If the buffer zones cannot clear, then the accumulator becomes a bottleneck.

Case Study: A Pre-Store Accumulator

This is the in-feed / drive side of the Rolco FILO (First-In, Last-Out) Accumulator, also showing bypass conveyors.

A large beverage manufacturer was experiencing low efficiency levels at their case packing operations. The cause was determined to be a high level of downtime associated with their case erectors, they could not maintain constant flow to the case packer when erectors came off and on line.

The solution was a fully integrated Rolco FILO (First-In, Last Out) case accumulator. In this application, Nercon integrated the case packer, case erector and a Vision inspection system to verify case quality. The Rolco Accumulator (a division of Nercon) was designed to pre-store cases to a 50% level during normal product changeover. This allowed the case erectors to build a surplus of cases to be used later when the case erectors malfunctioned. The excess capacity in the accumulator also allowed for continued case storage should the case packer not be packing at full speed.

The result was an increase in line efficiencies that paid for the investment within one year of service.

The equipment solution paid for itself within one year of service.

Communications and Controls

Communication between machines is important; they quickly identify when a downstream piece of equipment can no longer receive from upstream equipment. While basic controls will increase throughput of the entire line, a well thought-out controls plan can define the performance of the entire line. The system can be controlled to monitor upstream staging and downstream status; and slow down or speed-up machines to compensate for surges or to clear out accumulation zones. Operator panel stations are utilized to immediately diagnose machine status.

Consider the PLC Host. In an integrated system, each piece of equipment will, at a minimum, communicate it's “Ready to Receive” status to host PLC (Programmable Logic Controller.) Most often, the conveyor PLC serves as the line integration “host” PLC. The reason for this is that the conveyor system physically integrates all of the line equipment. It is a logical progression to have the PLC that controls the physical integration also control the logical integration of the system. By taking this approach, lower overall line costs are realized with a single host PLC and the best overall line integration can occur by utilizing all the inherent buffering capacity available from the conveyors themselves. Without integrated communications between all the equipment on the line, high levels of efficiency are never truly realized.

Controlling High Speeds

Buffering zones in high speed lines are generally needed in the immediate proximity of fillers and wrappers. The goal of high-speed buffering is to coordinate the operation of two or more high speed machines so that neither machine out paces the other; causing one machine to pause from either a product shortage or backlog condition. This is typically accomplished through a controls scheme that not only controls the conveyor speeds, but more importantly commands the rates of the high speed equipment. In high-speed lines, conveyor experts consider buffering methods in mass flow areas where the product velocity is slower.

Seek the advice of a conveyor manufacturer with expertise in your specific industry when researching accumulation in your packaging or process line. The type, design and capacity of the accumulation equipment and the conveyors themselves, are very specialized to your application. Experienced conveyor engineers and manufacturers will consider all the parameters such as line speed, efficiencies, type of product and available space in order to design the best overall production line with maximum throughput.

Nercon specializes in packaging line engineering and design, controls integration and conveyor manufacturing. Having a great depth of expertise in packaging and process industries, Nercon engineers are proficient at designing fully integrated and automated conveyor lines handling everything from cans, pouches, PET containers, paperboard containers, tubes, bottles to jars, trays, cartons and cases.

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